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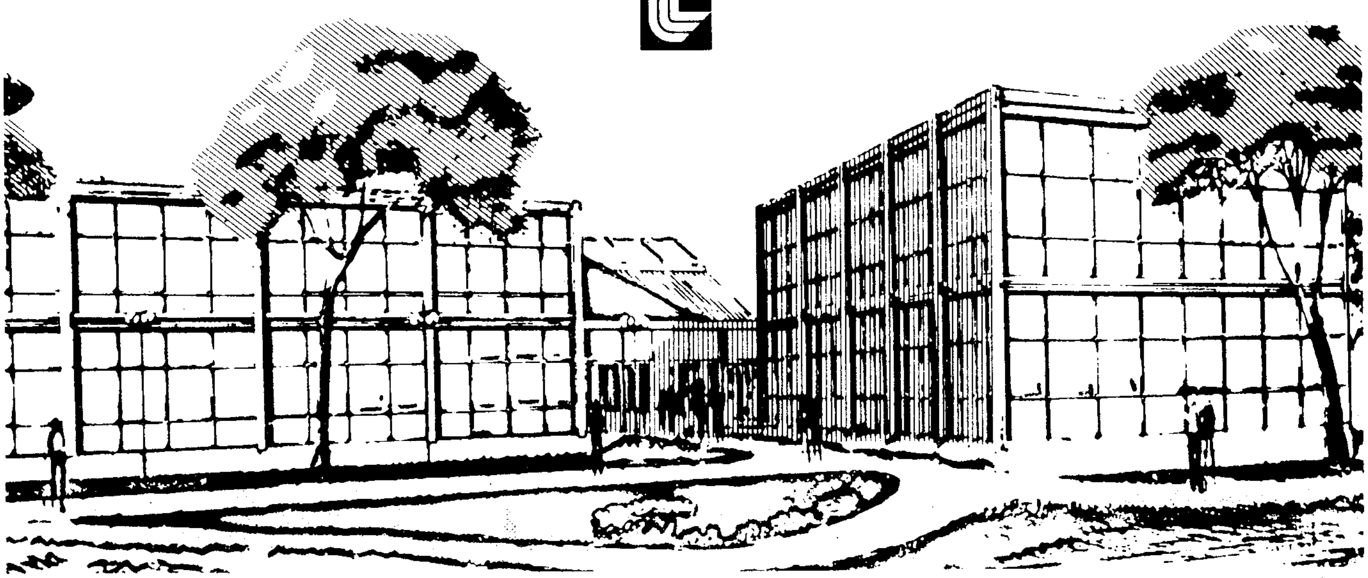

ABSTRACT

A method for predicting $\bar{\nu}(Z, A, E_n)$ is developed and tested against available experimental data ranging from Th^{229} to Cf^{249}. The only input values required are the charge and mass numbers (Z and A) and the binding energy of the last neutron in the A + 1 nucleus. For incident neutron energies greater than the threshold of multiple chance fission the method is extended by accounting for each fission process separately. This method is an extension of the author's work reported in 1963 and 1971.

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INTRODUCTION

Prediction of the average number of neutrons resulting from neutron-induced[1-5] or spontaneous fission has been a recurring question for the past quarter-century. Conventional fission reactors, coupled fusion-fission reactors, and other devices that depend upon the fission process all have in common the figure of merit: $\bar{\nu}(Z, A, E_n) \cdot \sigma_f(Z, A, E_n)$ [where E_n is the incident neutron energy]. More recently Meldner et al.[6] addressed the problem for super-heavy elements in the context of prediction of the spontaneous fission $\bar{\nu}(Z, A)$ for very neutron-rich isotopes produced in nuclear explosions. A need for a method of predicting $\bar{\nu}(Z, A, E_n)$ for all isotopes with $90 \leq Z \leq 99$ was dealt with at a recent International Atomic Energy Agency Advisory Group Meeting[7] in the context of using or disposing of trans-actinides produced in fast-fission breeder reactors.

The early work[1,2] dealt with the observable that $\bar{\nu}(E_n)$ for each isotope is reasonably represented by a linear function of E_n, if E_n is less than the threshold for second-chance fission. The work of Schuster and Howerton[3] developed a truncated pseudo-Taylor series for representation of $\bar{\nu}(92, A, E_n)$ including a method for extending the incident-neutron energy regime of applicability above the multiple-chance fission thresholds. Howerton's work[4] extended the method of Schuster and Howerton[3] to include a Z dependence by keeping all first order and one cross-product term of the pseudo-Taylor expansion. In both Refs. 3 and 4 the constants for the truncated pseudo-Taylor series were evaluated either directly or indirectly from experimental data. Manero and Konshin[5] presented:

a) a copious review of experimental data

b) a simple relationship between the spontaneous fission $\bar{\nu}(Z, A)$ and $\bar{\nu}(Z, A\text{-}1$, Thermal neutron energy)

c) a review of the methods of Gordeeva and Smirenkin[8] and Ping-Shin Tu and Prince,[9] both of which works provided methods for estimating $\bar{\nu}(Z, A, 0)$ as functions of Z and A (Ref. 8 presented a linear function of Z, A and a term related to pairing energy while Ref. 9 used $Z^2/A^{1/3}$ and $Z^2/\sqrt{A}$ in power series form)

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*Throughout this paper $E_n = 0$ refers to either 0.0253 eV or Thermal neutron energy.

d) power series fits up to order 5 for $\bar{\nu}(E_n)$ for various isotopes.

Meldner et al.[6] estimated $\bar{\nu}_{sp}$ by using the energy balance equation provided by Nix[10] which states effectively that the number of neutrons per fission is the quotient of the energy available for neutron emission from the fission fragments divided by the sum of the average separation energy and the average emitted neutron kinetic energy. They then derived average separation energies from mass calculations using Seeger and Howard's formula,[11] assumed a value for the average emitted neutron kinetic energy, assumed a Q-value for fission, assumed that the amount of fission energy that goes into photons is equal to the equivalent energy of one neutron per fission. From these assumptions and calculations they calculated $\bar{\nu}$ from the energy balance equation.

THEORETICAL DEVELOPMENT

It is clear that much of the past work has dealt with bits and pieces of predicting $\bar{\nu}(Z, A, E_n)$ and $\bar{\nu}_{sp}(Z, A)$. The development that will be presented here is a continuation of the work of Refs. 3 and 4 but with more detail of the assumptions and reasons for selecting the values about which the pseudo-Taylor expansion is made.

The following assumptions are made:

1. The average total kinetic energy of fission fragments is independent of incident neutron energy. This assumption is in agreement with observation.[12]
2. The average energy per fission that is emitted as prompt photons is constant.
3. The total energy released in fission is constant for all isotopes of an element.

With these assumptions, it is further assumed that a Taylor Series expansion in the three variables (Z, A, E_n) is valid. Thus:

$$\bar{\nu}(Z, A, E_n) \;\square\; T(Z, A, E_n) \quad . \tag{1}$$

The next problems are to determine the values of Z_0, A_0 and E_0 about which the expansion is to be made and the order of the terms in the series that are to be kept. For the Z_0 and A_0 values it seems most reasonable to use an isotope for which many measurements have been reported for $\bar{\nu}(Z_0, A_0, E_n)$. The values selected are $Z_0 = 92$ and $A_0 \;\square\; 235$. For E_0 the most reasonable candidate is the fission barrier for the nucleus in question. Since the fission barrier is not an observable *per se* a better candidate for E_0 is the threshold of the fission reaction (E_{Th}), since this quantity can be checked against an observable for those isotopes with a positive energy threshold; e.g., U^{238}, and

$$E_{Th} = E_{Barrier} - B_n - 0.9 \text{ MeV} \tag{2a}$$

where B_n is the binding energy of the last neutron in the A + 1 nucleus. The quantity (-0.9 MeV) accounts for the barrier penetration nature of the fission process and was derived from lifetime comparisons between fission and photon emission by Vandenbosch and Seaborg[13] who also presented a semi-empirical method for calculating the barrier energy. Comparisons with threshold energies suggest a modification of this value to 0.4. In Ref. 13 the variation of the fission barrier with even-even, even-odd, odd-even and odd-odd fissioning nuclei was dealt with by an argument based on spontaneous fission lifetimes. A more basic approach in light of current knowledge would be to make the argument in terms of pairing energies for the fissioning nucleus. The basic equation of Ref. 13 when combined with Eq. (2a) gives:

$$E_{Th} = 19.0 - 0.36\ Z^2/A - B_n - 0.4\ \text{MeV} \qquad (2b)$$

for fission of an even-even compound nucleus. It is to be expected that the barrier should be raised due to pairing energy considerations for odd-even and even-odd compound nuclei. From the same argument, one would expect the odd-odd compound nuclei to exhibit twice the effect as the odd-even and even-odd nuclei. Considerations of the binding energy of the last neutron in typical fission fragments lead to an estimate of the pairing energy correction of 0.4 MeV for odd mass compound nuclei. This leads to

$$\bar{\nu}_{Th}(Z, A) = 18.6 - 0.36\ Z^2/(A+1) + 0.2[2. - (-1)^{A+1} - (-1)^Z] - B_n \qquad (2c)$$

The threshold for fission can be obtained from Eq. (2c) using mass tables[14] derived from experiment or semi-empirical mass formulas such as that of Seeger and Howard.[11] Comparison of the fission thresholds calculated from the formula of Ref. 13 and the measured threshold energies (energy at which the cross section is one-half its plateau value) shows generally good agreement (within a few hundred keV). Of course, the comparison can be made only for those isotopes that have a positive threshold energy.

Using the assumptions that $\bar{\nu}(Z, A, E_n)$ varies linearly with the excitation of the fission fragments and that the energy released in photons is constant:

$$\bar{\nu} = kE_i = k(E_T - E_K - E_\gamma) \qquad (3)$$

where E_i, E_T, E_K and E_γ are the average internal, total, kinetic and photon energies released in fission. If k is the reciprocal of the product of the average separation energy of a neutron from a fission fragment by the average kinetic energy of a fission neutron, Eq. (3) becomes identical in content, but not in form, to the equation of Ref. 10 used in Ref. 6.

Assuming the proportionality of E_K to $Z^2/A^{1/3}$ as suggested in Ref. 1 and evaluated more recently in Ref. 12:

$$\frac{d\nu_{Th}}{\nu_{Th}} = \frac{dE_T}{E_i} + \frac{E_K}{E_i}\left(\frac{dA}{3A} - \frac{2dZ}{Z}\right) - \frac{dE_\gamma}{E_i} \quad . \tag{4}$$

Since E_T and E_γ are hypothesized to be constant for the isotopes of an element and evaluating Eq. (4) for uranium, dE_T, dE_γ and dZ are zero so that for U^{235}

$$\frac{d\bar{\nu}_{Th}}{dA} = \frac{E_K}{3E_i}\,\frac{\bar{\nu}_{Th}}{A} = \left(\frac{169}{3x22.5}\right)\left(\frac{2.33}{236}\right) \approx 0.02 \quad . \tag{5}$$

Since a pairing energy effect depending on the even odd characteristics of the charge and mass of the compound fissioning nucleus is to be expected, a term which modifies the threshold $\bar{\nu}$ value is included. Although it is possible to make arguments about the relative magnitudes of the binding energy of the last neutron in even-neutron and odd-neutron fission fragments before emission of fission neutrons and arrive at essentially the same value for the pairing energy contribution, the value used here was obtained from comparing the experimental $\bar{\nu}(E)$ values for U^{235} and U^{238} and is 0.12 neutrons per fission. Thus the ν_{Th} value is written:

$$\bar{\nu}_{Th}(Z, A) = 2.33 + 0.06[2. - (-1)^{A+1} - (-1)^{Z}] \quad . \tag{6}$$

If the average total fission fragment energy equation of Refs. 1 and 12 included a pairing energy term, it should be possible to calculate the constant or, conversely, this implies that a pairing energy term should be included in the equation. The magnitude of such a term, however, would be such that it would be masked by the uncertainty in the experimental data.

The problem remains to determine the order of truncation of the Taylor Series representation of $\bar{\nu}(Z, A, E_n)$. Clearly, the simplest truncation would be to keep only first order terms but, since it is known empirically that for a single element the energy dependence is different for different isotopes, the cross product term involving energy and mass should also be included. Following this simplest approximation (all first order terms plus the energy-mass cross term) the expansion can be written:

$$\bar{\nu}(Z,A,E_n) = C_0 + C_1(Z-92) + C_2(A-235) + C_3(E-E_{Th}) + C_4(A-235) \quad (E-E_n) + O(Z,A,E) \; . \tag{7}$$

The constant C_0 is evaluated from Eq. (6) for U^{235}; C_2 is given by Eq. (5); C_3 is determined from the slope of $\bar{\nu}(92, 235, E_n)$ experimental values and equals 0.130; C_4 is determined from comparison of fits to experimental data for U^{235} and U^{238} and equals 0.006; C_1, which supplies the Z dependence, is obtained from a comparison of Pu^{239} and U^{235} experimental data and equals 0.15. The resulting equation:

$$\bar{\nu}(Z,A,E_n) = 2.39 + 0.06[2. - (-1)^{A+1} - (-1)^{Z}] + 0.15(Z-92) + 0.02(A-235) + [0.130 + 0.006(A-235)](E - E_{Th}) \tag{8}$$

differs from Eq. (3) of Ref. 4 only in the second term.

The extension of Eq. (2c) and Eq. (8) to applicability in the neutron energy regime where multiple chance fission can occur requires:

1. Estimating the probabilities of successive chance fission.
2. Estimating the mean kinetic energy of the emitted pre-seisson neutrons.
3. Taking proper account of binding energies of the last neutron in the various fissioning isotopes.

After combining the first four terms of Eq. (8) to obtain the value of $\bar{\nu}(Z, A, E_{Th})$

$$\bar{\nu}_{Th}(Z, A) = 2.39 + 0.06[2. - (-1)^{A+1} - (-1)^{Z}] + 0.15(Z-92) + 0.02(A-235) \tag{9}$$

and defining the first factor of the fourth term of Eq. (8) to be

$$\bar{\nu}_1(A) = 0.130 + 0.006(A-235) \; , \tag{10}$$

the following relationship is obtained which applies both above and below the threshold for multiple chance fission.

$$\bar{\nu}(Z,A,E_n) = \sum_{n=0}^{M} R_n \times \{n + \bar{\nu}_{Th}(A - n,Z) + \nu_1(A - n) \times [E_n - E_B(A) + E_B(A - n) - n \times \bar{E}_T(n) - E_{Th}(A - n)]\} \quad . \tag{11}$$

where: R_n are the fractions of the total fission cross section going to each process; i.e.,

$$R_0(E_n) = \frac{\sigma_{\text{direct fission}}(E_n)}{\sigma_{\text{Total fission}}(E_n)} \quad ;$$

$$R_1(E_n) = \frac{\sigma_{nn'f}(E_n)}{\sigma_{\text{Total fission}}(E_n)} \quad ;$$

$$R_2(E_n) = \frac{\sigma_{n,2nf}(E_n)}{\sigma_{\text{Total fission}}(E_n)} \quad ; \text{ etc.}$$

$E_B(A)$ = total binding energy of the nucleus with charge Z and mass A;

$E_T(n)$ = mean energy of pre-scission neutrons;

$E_{Th}(A-n)$ = threshold energy of the fission process for the nucleus with charge Z and mass (A - n).

M = the degree of multiple chance fission to be taken into account.

Estimates of the R_n and $E_T(n)$ values were given by Howerton in Ref. 4 and were obtained from considerations of nuclear systematics and available energy.

COMPARISON WITH EXPERIMENT

Values of $\bar{\nu}(Z, A, E_n)$ calculated from Eq. (8) with experimental data agree surprisingly well with measured values, especially since the constants of Eq. (8) are of only one or two figure significance. Tables 1 through 9 present values of $\bar{\nu}(Z, A, E_n)$ calculated using Eq. (8) together with appropriate experimental values. The threshold values used were taken from experiment where the fission cross section has a positive threshold and has been measured. For U^{233}, U^{235}, Pu^{239} and Pu^{241} the threshold was determined such that the zero neutron energy value of $\bar{\nu}(Z, A)$ agreed with the recommended values of Ref. 5 after renormalization to a value of 3.73 for $\bar{\nu}$ spontaneous of Cf^{252}. The experimental values presented in Tables 1 - 9 were likewise renormalized to the same value. Since the threshold is difficult to determine from measured fission cross sections to an accuracy greater than ±100 keV, the observed threshold was adjusted slightly for Th^{232}, U^{234}, U^{236}, U^{238} and Pu^{240} such that the weighted mean of the ratio of calculated to experimental $\bar{\nu}(Z, A, E_n)$ values was essentially unity. The only pathological deviation is noted in the first three values of Table 1 where there is a suggestion of rising $\bar{\nu}$ with decreasing energy.

To test further the adequacy of Eq. (8) in the order of the energy term, least-squares fitting for several isotopes was undertaken. The experimental data were weighted with the reciprocal of the experimental error and fits were obtained using a standard least-squares method. In no case was a significantly better fit obtained by including higher order (up to order 5) terms in neutron energy.

There have been relatively few measurements of $\bar{\nu}(Z, A, E_n)$ for isotopes other than those represented in Tables 1 - 9. One series of zero-energy measurements was reported by Jaffey and Lerner.[49] Table 10 presents their experimental results and calculated values using Eq. (8) and the calculated thresholds from Eq. (2c) for the isotopes not included in Tables 1 - 9. The experimental values of Table 10 were renormalized to the value of 3.73 for the spontaneous fission $\bar{\nu}$ of Cf^{252}. The anomaly associated with the zero energy $\bar{\nu}$ of U^{232} was remarked upon by the experimentalists who stated that there were problems with their apparatus which caused this measurement to be less satisfactory than the other measurements they reported. A single measurement for zero neutron energy $\bar{\nu}$ has been reported in Ref. 51 for Cf^{249}. The experimental value is 4.03 ± 0.04 and the value calculated from Eqs. (2c) and (8) is 4.00.

CONCLUSIONS

Expanding the charge, mass, and energy dependence of $\bar{\nu}$ in the form of a truncated Taylor Series apparently yields a reasonable representation for $\bar{\nu}(Z, A, E_n)$ if the zero- , first- and one second-order cross term are kept in the truncation. The comparison of calculated with experimental data displayed in Tables 1 - 10 indicate that, in general, agreement can be expected to within 5 percent for isotopes ranging from Th^{229} to Cm^{245}. The agreement with the zero energy value for Cf^{249} to less than one percent may, of course, be fortuitous but the method for predicting $\bar{\nu}(Z, A, E_n)$ appears to be satisfactory for a large range in charge and mass. There is no indication that keeping more terms of the Taylor Series representation would yield better agreement with experiment.

Using Eqs. (2c) and (8) for prediction may or may not be valid for very neutron-rich isotopes such as those discussed by Meldner et al.[6] If such predictive calculations are carried out, the results do not agree with those reported in Ref. 6.

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Table 1. Comparison of calculated values of $\bar{\nu}$ for Th^{232} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
1.390	2.287	0.076	0.033	2.088	0.913	65- 15
1.420	2.179	0.060	0.028	2.091	0.960	65- 16
1.480	2.146	0.096	0.045	2.098	0.978	68- 17
1.560	2.064	0.073	0.035	2.107	1.021	68- 17
1.610	2.060	0.037	0.018	2.112	1.025	65- 16
1.640	2.100	0.072	0.034	2.116	1.008	68- 17
1.800	2.093	0.055	0.026	2.134	1.019	65- 16
1.980	2.181	0.034	0.016	2.154	0.988	65- 15
2.050	2.110	0.069	0.033	2.162	1.024	68- 17
2.230	2.154	0.049	0.023	2.182	1.013	65- 16
2.460	2.187	0.052	0.024	2.208	1.009	68- 17
2.640	2.246	0.052	0.023	2.228	0.992	65- 16
2.860	2.179	0.054	0.025	2.252	1.034	68- 17
3.000	2.254	0.095	0.042	2.268	1.006	65- 15
3.270	2.379	0.074	0.031	2.298	0.966	68- 17
3.600	2.383	0.100	0.042	2.335	0.980	65- 16
4.020	2.377	0.067	0.028	2.382	1.002	65- 15

Table 2. Comparison of calculated values of $\bar{\nu}$ for U^{233} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF	
0.	2.446	0.022	0.009	2.453	1.003	63-	18
0.	2.498	0.031	0.012	2.453	0.982	65-	15
0.	2.455	0.024	0.010	2.453	0.999	55-	19
0.	2.479	0.100	0.040	2.453	0.989	55-	20
0.	2.432	0.024	0.010	2.453	1.009	59-	21
0.	2.456	0.008	0.003	2.453	0.999	67-	22
0.	2.506	0.040	0.016	2.453	0.979	66-	23
0.	2.444	0.014	0.006	2.453	1.004	65-	24
0.	2.425	0.063	0.026	2.453	1.011	58-	25
0.	2.396	0.038	0.016	2.453	1.024	56-	26
0.280	2.462	0.033	0.013	2.486	1.010	63-	18
0.300	2.467	0.014	0.006	2.488	1.009	70-	27
0.440	2.475	0.033	0.013	2.505	1.012	63-	18
0.490	2.473	0.010	0.004	2.511	1.015	70-	27
0.580	2.433	0.050	0.021	2.521	1.036	63-	28
0.600	2.511	0.012	0.005	2.524	1.005	70-	27
0.700	2.511	0.011	0.004	2.535	1.010	70-	27
0.920	2.528	0.012	0.005	2.561	1.013	70-	27
0.930	2.522	0.050	0.020	2.563	1.016	63-	28
0.960	2.498	0.036	0.014	2.566	1.027	65-	15
0.980	2.525	0.035	0.014	2.568	1.017	63-	18
1.000	2.483	0.030	0.012	2.580	1.039	63-	18
1.490	2.483	0.100	0.040	2.629	1.059	63-	28
1.500	2.608	0.019	0.007	2.630	1.008	70-	27
1.870	2.647	0.022	0.008	2.673	1.010	70-	27
1.980	2.603	0.033	0.013	2.686	1.032	65-	15
2.120	2.542	0.050	0.020	2.703	1.063	63-	28
2.580	2.771	0.060	0.022	2.757	0.995	63-	28
3.000	2.815	0.038	0.013	2.807	0.997	65-	15
3.930	2.951	0.040	0.014	2.917	0.988	63-	18
4.000	2.883	0.043	0.015	2.925	1.015	65-	15

Table 3. Comparison of calculated values of $\bar{\nu}$ for U^{234} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
0.990	2.437	0.046	0.019	2.483	1.019	65- 15
1.980	2.641	0.033	0.012	2.606	0.987	65- 15
3.000	2.692	0.043	0.016	2.733	1.015	65- 15
4.000	2.885	0.056	0.019	2.857	0.990	65- 15

Table 4. Comparison of calculated values of $\bar{\nu}$ for U^{235} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
0.	2.396	0.026	0.011	2.383	0.995	65- 24
0.	2.450	0.150	0.061	2.383	0.973	56- 26
0.	2.399	0.020	0.008	2.383	0.993	63- 18
0.	2.398	0.080	0.033	2.383	0.994	66- 23
0.	2.380	0.014	0.006	2.383	1.001	66- 29
0.	2.400	0.040	0.017	2.383	0.993	66- 30
0.	2.379	0.020	0.008	2.383	1.002	64- 31
0.	2.382	0.008	0.003	2.383	1.001	70- 32
0.	2.387	0.023	0.010	2.383	0.998	65- 33
0.	2.378	0.014	0.006	2.383	1.002	70- 34
0.040	2.388	0.017	0.007	2.388	1.000	67- 35
0.040	2.386	0.014	0.006	2.388	1.001	65- 15
0.050	2.389	0.016	0.007	2.390	1.000	67- 35
0.060	2.392	0.023	0.010	2.391	1.000	65- 33
0.080	2.386	0.024	0.010	2.394	1.003	64- 36
0.080	2.371	0.014	0.006	2.394	1.010	70- 34
0.080	2.339	0.035	0.015	2.394	1.023	64- 36
0.100	2.449	0.047	0.019	2.396	0.978	63- 28
0.110	2.383	0.021	0.009	2.398	1.006	70- 32
0.140	2.389	0.042	0.018	2.401	1.005	65- 15
0.150	2.423	0.018	0.007	2.403	0.990	67- 35
0.190	2.395	0.030	0.016	2.408	1.005	64- 36
0.210	2.432	0.020	0.008	2.411	0.991	70- 34
0.210	2.391	0.054	0.023	2.411	1.008	69- 37
0.220	2.411	0.015	0.006	2.412	1.000	70- 32
0.230	2.456	0.022	0.009	2.413	0.983	65- 15
0.230	2.446	0.018	0.007	2.413	0.987	67- 35
0.230	2.406	0.041	0.017	2.413	1.003	69- 37
0.250	2.423	0.037	0.015	2.416	0.997	69- 37
0.270	2.452	0.031	0.013	2.418	0.986	69- 37
0.270	2.436	0.022	0.009	2.418	0.993	67- 35
0.280	2.411	0.022	0.009	2.420	1.004	[illegible]- 18
0.290	2.420	0.029	0.012	2.421	1.000	69- 37
0.290	2.429	0.034	0.014	2.421	0.997	64- 36
0.300	2.438	0.022	0.009	2.422	0.994	67- 35
0.300	2.414	0.017	0.007	2.422	1.003	70- 32
0.310	2.429	0.026	0.011	2.424	0.998	69- 37
0.310	2.429	0.022	0.009	2.424	0.998	64- 36
0.320	2.423	0.020	0.008	2.425	1.001	70- 34
0.330	2.479	0.018	0.007	2.426	0.979	67- 35
0.330	2.405	0.024	0.010	2.426	1.009	69- 37
0.330	2.444	0.021	0.009	2.426	0.993	65- 15
0.350	2.422	0.016	0.007	2.429	1.003	70- 32
0.350	2.475	0.024	0.010	2.429	0.981	69- 37
0.360	2.402	0.018	0.007	2.430	1.012	67- 35
0.370	2.433	0.023	0.009	2.431	0.999	69- 37
0.370	2.436	0.017	0.007	2.431	0.998	67- 17
0.380	2.443	0.022	0.009	2.433	0.996	67- 35
0.390	2.437	0.017	0.007	2.434	0.999	64- 36
0.390	2.438	0.023	0.009	2.434	0.998	69- 37

Table 4 (contd)

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP	YR-REF
0.400	2.405	0.016	0.007	2.435	1.013	70- 32
0.410	2.491	0.021	0.008	2.437	0.978	69- 37
0.410	2.440	0.024	0.010	2.437	0.999	70- 34
0.410	2.434	0.022	0.009	2.437	1.001	67- 35
0.430	2.456	0.021	0.009	2.439	0.993	69- 37
0.430	2.422	0.011	0.005	2.439	1.007	70- 32
0.430	2.441	0.020	0.008	2.439	0.999	65- 15
0.430	2.499	0.017	0.007	2.439	0.976	67- 35
0.450	2.436	0.018	0.007	2.442	1.002	69- 37
0.450	2.422	0.014	0.006	2.442	1.008	70- 32
0.460	2.439	0.037	0.015	2.443	1.002	64- 36
0.470	2.416	0.018	0.007	2.444	1.012	69- 37
0.470	2.429	0.022	0.009	2.444	1.006	63- 18
0.480	2.477	0.019	0.008	2.446	0.987	67- 35
0.490	2.460	0.016	0.007	2.447	0.995	69- 37
0.490	2.440	0.010	0.004	2.447	1.003	70- 32
0.510	2.492	0.044	0.018	2.450	0.983	63- 28
0.510	2.456	0.016	0.007	2.450	0.997	69- 37
0.510	2.450	0.027	0.011	2.450	1.000	70- 34
0.530	2.474	0.016	0.006	2.452	0.991	69- 37
0.540	2.422	0.013	0.005	2.453	1.013	70- 32
0.550	2.455	0.017	0.007	2.455	1.000	67- 35
0.550	2.432	0.015	0.006	2.455	1.009	69- 37
0.550	2.388	0.022	0.009	2.455	1.028	64- 36
0.570	2.471	0.029	0.012	2.457	0.994	63- 28
0.570	2.480	0.026	0.010	2.457	0.991	63- 28
0.570	2.448	0.014	0.006	2.457	1.004	69- 37
0.590	2.433	0.035	0.014	2.460	1.011	67- 17
0.590	2.432	0.014	0.006	2.460	1.012	69- 37
0.600	2.484	0.023	0.009	2.461	0.991	63- 28
0.600	2.442	0.014	0.006	2.461	1.008	70- 32
0.610	2.453	0.017	0.007	2.463	1.004	69- 37
0.630	2.452	0.016	0.007	2.465	1.005	69- 37
0.640	2.415	0.038	0.016	2.466	1.021	64- 36
0.650	2.405	0.039	0.016	2.468	1.026	70- 38
0.650	2.470	0.017	0.007	2.468	0.999	69- 37
0.670	2.418	0.022	0.009	2.470	1.022	64- 36
0.670	2.459	0.017	0.007	2.470	1.005	69- 37
0.680	2.420	0.039	0.016	2.472	1.021	70- 38
0.680	2.479	0.017	0.007	2.472	0.997	67- 35
0.690	2.452	0.020	0.008	2.473	1.009	69- 37
0.690	2.418	0.025	0.010	2.473	1.023	70- 34
0.700	2.458	0.014	0.006	2.474	1.007	70- 32
0.700	2.423	0.016	0.007	2.474	1.021	65- 15
0.710	2.444	0.039	0.016	2.476	1.013	70- 38
0.725	2.455	0.013	0.005	2.478	1.009	69- 37
0.730	2.445	0.039	0.016	2.478	1.014	70- 38
0.775	2.480	0.014	0.006	2.484	1.002	69- 37
0.780	2.418	0.025	0.010	2.485	1.028	64- 36
0.790	2.492	0.014	0.006	2.486	0.998	67- 35

Table 4 (contd)

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF	
0.790	2.450	0.039	0.016	2.486	1.015	70-	38
0.810	2.480	0.020	0.008	2.489	1.003	70-	34
0.810	2.424	0.035	0.014	2.489	1.027	67-	17
0.820	2.444	0.026	0.011	2.490	1.019	63-	18
0.820	2.463	0.040	0.016	2.490	1.011	70-	38
0.825	2.493	0.015	0.006	2.491	0.999	69-	37
0.840	2.494	0.021	0.008	2.492	0.999	65-	15
0.870	2.446	0.039	0.016	2.496	1.021	70-	38
0.875	2.506	0.017	0.007	2.497	0.996	69-	37
0.910	2.471	0.040	0.016	2.502	1.012	70-	38
0.910	2.483	0.026	0.010	2.502	1.007	70-	34
0.925	2.508	0.017	0.007	2.504	0.998	69-	37
0.930	2.455	0.020	0.008	2.504	1.016	65-	15
0.950	2.498	0.020	0.008	2.507	1.004	63-	28
0.970	2.456	0.039	0.016	2.509	1.022	70-	38
0.975	2.513	0.019	0.008	2.510	0.999	69-	37
0.990	2.449	0.029	0.012	2.512	1.026	64-	36
1.000	2.522	0.025	0.010	2.513	0.997	70-	34
1.000	2.526	0.016	0.006	2.513	0.995	67-	35
1.000	2.502	0.014	0.006	2.513	1.005	70-	32
1.010	2.463	0.039	0.016	2.515	1.021	70-	38
1.020	2.500	0.027	0.011	2.516	1.006	67-	17
1.025	2.506	0.023	0.009	2.517	1.004	69-	37
1.060	2.511	0.038	0.015	2.521	1.004	70-	38
1.075	2.537	0.024	0.009	2.523	0.995	69-	37
1.080	2.503	0.026	0.010	2.524	1.008	63-	18
1.110	2.542	0.022	0.009	2.528	0.994	70-	34
1.125	2.537	0.028	0.011	2.530	0.997	69-	37
1.150	2.546	0.038	0.015	2.533	0.995	70-	38
1.170	2.521	0.021	0.008	2.535	1.006	65-	15
1.175	2.535	0.029	0.011	2.536	1.000	69-	37
1.275	2.537	0.030	0.012	2.543	1.002	69-	37
1.230	2.517	0.037	0.015	2.543	1.010	67-	17
1.250	2.549	0.038	0.015	2.546	0.999	70-	38
1.275	2.595	0.040	0.015	2.549	0.982	65-	37
1.310	2.538	0.024	0.009	2.554	1.006	70-	34
1.325	2.517	0.040	0.016	2.556	1.015	69-	37
1.350	2.504	0.039	0.015	2.559	0.950	70-	38
1.360	2.524	0.017	0.007	2.560	1.014	69-	37
1.360	2.524	0.010	0.004	2.560	1.014	69-	37
1.375	2.541	0.032	0.013	2.562	1.008	69-	37
1.410	2.589	0.039	0.015	2.567	0.991	70-	38
1.440	2.525	0.037	0.015	2.570	1.018	67-	17
1.470	2.547	0.020	0.008	2.574	1.011	65-	15
1.480	2.607	0.039	0.015	2.576	0.988	70-	38
1.500	2.555	0.020	0.008	2.578	1.009	63-	28
1.500	2.553	0.018	0.007	2.578	1.010	70-	32
1.520	2.536	0.025	0.010	2.581	1.018	70-	34
1.630	2.612	0.039	0.015	2.595	0.994	70-	38
1.640	2.550	0.036	0.014	2.596	1.018	67-	17

Table 4 (contd)

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF	
1.800	2.612	0.039	0.015	2.617	1.002	70-	38
1.850	2.580	0.034	0.013	2.624	1.017	67-	17
1.870	2.589	0.022	0.008	2.626	1.014	69-	37
1.900	2.589	0.016	0.006	2.630	1.016	70-	32
1.940	2.620	0.021	0.008	2.635	1.006	65-	15
1.970	2.616	0.039	0.015	2.639	1.009	70-	38
2.050	2.632	0.040	0.015	2.650	1.007	70-	38
2.050	2.568	0.031	0.012	2.650	1.032	67-	17
2.120	2.646	0.021	0.008	2.659	1.005	63-	28
2.180	2.669	0.033	0.012	2.667	0.999	70-	38
2.250	2.637	0.037	0.014	2.676	1.015	67-	17
2.260	2.682	0.035	0.013	2.677	0.998	70-	38
2.330	2.630	0.026	0.010	2.686	1.021	69-	37
2.390	2.717	0.035	0.013	2.694	0.992	70-	38
2.440	2.653	0.022	0.008	2.700	1.018	65-	15
2.450	2.645	0.022	0.008	2.702	1.021	69-	37
2.460	2.718	0.042	0.015	2.703	0.995	67-	17
2.550	2.680	0.035	0.013	2.715	1.013	70-	38
2.570	2.689	0.024	0.009	2.717	1.011	63-	28
2.680	2.732	0.033	0.012	2.732	1.000	70-	38
2.760	2.773	0.038	0.014	2.742	0.989	67-	17
2.850	2.781	0.034	0.012	2.754	0.990	70-	38
2.940	2.775	0.034	0.012	2.765	0.997	70-	38
2.960	2.713	0.016	0.006	2.768	1.020	65-	15
2.980	2.714	0.018	0.007	2.771	1.021	69-	37
3.060	2.782	0.059	0.021	2.781	1.000	67-	17
3.060	2.769	0.034	0.012	2.781	1.004	70-	38
3.250	2.809	0.046	0.016	2.806	0.995	67-	17
3.280	2.802	0.043	0.015	2.810	1.003	70-	38
3.500	2.760	0.023	0.008	2.838	1.028	69-	37
3.710	2.839	0.043	0.015	2.866	1.009	70-	38
3.870	2.893	0.022	0.008	2.886	[illegible]	65-	15
3.930	2.906	0.030	0.010	2.894	0.996	63-	18
3.930	2.837	0.026	0.009	2.894	1.020	69-	37
4.030	2.845	0.019	0.007	2.907	1.022	69-	37
4.230	2.871	0.044	0.015	2.933	1.022	70-	38
4.430	2.931	0.028	0.010	2.959	1.010	69-	37
4.540	2.937	0.022	0.007	2.973	1.012	69-	37
4.570	2.904	0.058	0.020	2.977	1.025	70-	38
4.900	2.998	0.061	0.020	3.020	1.007	70-	38
4.910	3.032	0.037	0.012	3.022	0.997	65-	15
4.940	3.016	0.028	0.009	3.025	1.003	69-	37
5.060	2.993	0.019	0.006	3.041	1.016	69-	37
5.320	3.061	0.072	0.024	3.075	1.005	70-	38
5.570	3.115	0.028	0.009	3.107	0.998	69-	37
5.600	3.076	0.082	0.027	3.111	1.011	70-	38
5.940	3.198	0.105	0.033	3.155	0.987	70-	38
5.940	3.229	0.025	0.008	3.155	0.977	65-	15
5.980	3.250	0.038	0.012	3.161	0.973	69-	37

Table 5. Comparison of calculated values of $\bar{\nu}$ for U^{236} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
0.770	2.433	0.060	0.025	2.388	0.982	71- 39
0.820	2.383	0.050	0.021	2.395	1.005	71- 39
0.880	2.423	0.050	0.021	2.403	0.992	71- 39
0.980	2.453	0.050	0.020	2.417	0.985	71- 39
1.000	2.413	0.050	0.021	2.431	1.007	71- 39
1.290	2.483	0.040	0.016	2.459	0.990	71- 39
1.500	2.542	0.040	0.016	2.488	0.979	71- 39
1.690	2.503	0.050	0.020	2.514	1.004	71- 39
1.900	2.532	0.040	0.016	2.542	1.004	71- 39
2.210	2.532	0.040	0.016	2.584	1.021	71- 39
2.290	2.671	0.050	0.019	2.595	0.972	71- 39
2.510	2.572	0.040	0.016	2.625	1.021	71- 39
2.590	2.652	0.050	0.019	2.636	0.994	71- 39
2.790	2.652	0.050	0.019	2.663	1.004	71- 39
2.990	2.701	0.050	0.019	2.690	0.996	71- 39
3.290	2.761	0.050	0.018	2.731	0.989	71- 39
3.790	2.791	0.050	0.018	2.799	1.003	71- 39
4.170	2.830	0.040	0.014	2.851	1.007	71- 39
5.500	2.940	0.060	0.020	3.032	1.031	71- 39

Table 6. Comparison of calculated values of $\bar{\nu}$ for U^{238} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
1.270	2.486	0.055	0.022	2.483	0.999	72- 40
1.300	2.481	0.052	0.021	2.488	1.003	72- 40
1.330	2.526	0.051	0.020	2.492	0.987	72- 40
1.350	2.557	0.049	0.019	2.495	0.976	72- 40
1.360	2.511	0.030	0.012	2.497	0.994	69- 37
1.410	2.534	0.034	0.013	2.504	0.988	65- 15
1.420	2.573	0.046	0.018	2.506	0.974	72- 40
1.450	2.573	0.046	0.018	2.510	0.976	72- 40
1.480	2.501	0.045	0.018	2.514	1.005	72- 40
1.490	2.490	0.056	0.022	2.516	1.010	64- 41
1.510	2.453	0.044	0.018	2.519	1.027	72- 40
1.550	2.450	0.042	0.017	2.525	1.031	72- 40
1.580	2.558	0.044	0.017	2.529	0.989	72- 40
1.620	2.559	0.041	0.016	2.535	0.991	72- 40
1.700	2.621	0.042	0.016	2.547	0.972	72- 40
1.780	2.505	0.041	0.016	2.559	1.021	72- 40
1.820	2.571	0.041	0.016	2.565	0.998	72- 40
1.870	2.555	0.030	0.012	2.572	1.007	69- 37
1.870	2.568	0.041	0.016	2.572	1.002	72- 40
1.920	2.525	0.041	0.016	2.580	1.022	72- 40
1.970	2.603	0.039	0.015	2.587	0.994	72- 40
1.980	2.621	0.022	0.008	2.588	0.988	65- 15
2.020	2.573	0.039	0.015	2.594	1.008	72- 40
2.070	2.569	0.041	0.016	2.602	1.013	72- 40
2.130	2.594	0.039	0.015	2.611	1.006	72- 40
2.180	2.592	0.039	0.015	2.618	1.010	72- 40
2.240	2.600	0.042	0.016	2.627	1.010	72- 40
2.310	2.635	0.042	0.016	2.637	1.001	72- 40
2.330	2.582	0.030	0.012	2.640	1.023	69- 37
2.370	2.661	0.043	0.016	2.646	0.994	72- 40
2.400	2.640	0.051	0.019	2.651	1.004	64- 41
2.440	2.689	0.043	0.016	2.657	0.988	72- 40
2.450	2.599	0.030	0.012	2.658	1.023	69- 37
2.510	2.634	0.042	0.016	2.667	1.012	72- 40
2.590	2.591	0.044	0.017	2.679	1.034	72- 40
2.660	2.612	0.045	0.017	2.689	1.030	72- 40
2.740	2.595	0.044	0.017	2.701	1.041	72- 40
2.830	2.643	0.045	0.017	2.714	1.027	72- 40
2.920	2.626	0.047	0.018	2.728	1.039	72- 40
2.960	2.636	0.023	0.009	2.736	1.038	69- 37
3.000	2.749	0.024	0.009	2.739	0.997	65- 15
3.110	2.670	0.048	0.018	2.756	1.032	72- 40
3.210	2.702	0.049	0.018	2.770	1.025	72- 40
3.320	2.702	0.049	0.018	2.787	1.031	72- 40
3.430	2.793	0.053	0.019	2.803	1.004	72- 40
3.500	2.830	0.049	0.017	2.813	0.994	64- 41
3.500	2.755	0.029	0.011	2.813	1.021	69- 37
3.550	2.759	0.053	0.019	2.821	1.022	72- 40
3.680	2.800	0.056	0.020	2.840	1.014	72- 40
3.800	2.840	0.057	0.020	2.858	1.006	72- 40

Table 6 (contd)

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
3.930	2.839	0.027	0.010	2.877	1.013	69- 37
3.940	2.866	0.050	0.020	2.879	1.004	72- 40
4.020	2.932	0.025	0.009	2.890	0.986	65- 15
4.030	2.838	0.023	0.008	2.892	1.019	69- 37
4.090	2.891	0.061	0.021	2.901	1.003	72- 40
4.240	2.856	0.058	0.020	2.923	1.023	72- 40
4.430	2.907	0.030	0.010	2.951	1.015	69- 37
4.500	2.960	0.057	0.019	2.961	1.000	72- 40
4.540	2.915	0.027	0.009	2.967	1.018	69- 37
4.860	3.002	0.057	0.019	3.015	1.004	72- 40
4.880	3.031	0.049	0.016	3.018	0.996	64- 41
4.940	3.014	0.030	0.010	3.027	1.004	69- 37
5.060	3.033	0.024	0.008	3.044	1.004	69- 37
5.390	3.074	0.080	0.026	3.093	1.006	72- 40
5.570	3.092	0.035	0.011	3.120	1.009	69- 37
5.620	3.164	0.092	0.029	3.127	0.988	72- 40
5.630	3.121	0.059	0.019	3.129	1.002	64- 41
5.870	3.162	0.092	0.029	3.164	1.001	72- 40
5.980	3.209	0.039	0.012	3.180	0.991	69- 37

Table 7. Comparison of calculated values of $\bar{\nu}$ for Pu^{239} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
0.	2.861	0.100	0.035	2.847	0.995	55- 20
0.	2.837	0.024	0.008	2.847	1.004	55- 19
0.	2.851	0.029	0.010	2.847	0.999	58- 42
0.	2.932	0.024	0.008	2.847	0.971	59- 21
0.	2.784	0.026	0.009	2.847	1.023	56- 26
0.	2.891	0.039	0.013	2.847	0.985	65- 15
0.	2.832	0.017	0.006	2.847	1.005	65- 24
0.	2.863	0.008	0.003	2.847	0.994	67- 22
0.	2.983	0.070	0.023	2.847	0.954	58- 25
0.	2.800	0.028	0.010	2.847	1.017	63- 18
0.	2.864	0.015	0.005	2.847	0.994	72- 43
0.080	2.854	0.027	0.009	2.859	1.002	70- 44
0.080	2.872	0.020	0.010	2.859	0.996	72- 43
0.080	2.868	0.026	0.009	2.859	0.997	72- 43
0.200	2.892	0.028	0.010	2.878	0.995	72- 43
0.200	2.893	0.029	0.010	2.878	0.995	70- 44
0.200	2.853	0.013	0.005	2.878	1.009	72- 45
0.210	2.851	0.094	0.033	2.879	1.010	69- 37
0.230	2.873	0.059	0.021	2.882	1.003	69- 37
0.250	2.900	0.039	0.013	2.886	0.995	63- 18
0.250	2.809	0.049	0.017	2.886	1.027	69- 37
0.270	2.843	0.042	0.015	2.889	1.016	69- 37
0.290	2.834	0.036	0.013	2.892	1.020	69- 37
0.300	2.886	0.024	0.008	2.893	1.003	72- 43
0.310	2.885	0.032	0.011	2.895	1.003	69- 37
0.330	2.911	0.031	0.011	2.898	0.995	69- 37
0.350	2.895	0.027	0.009	2.901	1.002	70- 44
0.350	2.874	0.016	0.006	2.901	1.009	72- 45
0.350	2.901	0.030	0.010	2.901	1.000	69- 37
0.370	2.891	0.030	0.010	2.904	1.005	69- 37
0.390	2.913	0.027	0.009	2.907	0.998	69- 37
0.400	2.894	0.017	0.006	2.909	1.005	72- 43
0.410	2.889	0.028	0.010	2.910	1.007	69- 37
0.420	2.926	0.040	0.014	2.912	0.995	63- 18
0.430	2.918	0.025	0.009	2.913	0.998	69- 37
0.450	2.891	0.023	0.008	2.916	1.009	69- 37
0.450	2.959	0.029	0.010	2.916	0.986	70- 44
0.470	2.911	0.022	0.008	2.919	1.003	69- 37
0.490	2.875	0.019	0.007	2.923	1.017	69- 37
0.500	2.925	0.026	0.009	2.924	1.000	72- 43
0.510	2.922	0.018	0.006	2.926	1.001	69- 37
0.530	2.883	0.017	0.006	2.929	1.016	69- 37
0.550	2.897	0.017	0.006	2.932	1.012	72- 45
0.550	2.944	0.038	0.013	2.932	0.996	70- 44
0.550	2.934	0.029	0.010	2.932	0.999	72- 43
0.550	2.971	0.028	0.009	2.932	0.987	70- 44
0.550	2.914	0.017	0.006	2.932	1.006	69- 37
0.570	2.914	0.016	0.005	2.935	1.007	69- 37
0.590	2.890	0.018	0.006	2.938	1.017	69- 37
0.600	2.919	0.025	0.009	2.939	1.007	72- 43

Table 7 (contd)

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
0.600	2.878	0.038	0.013	2.939	1.021	70- 44
0.610	2.843	0.041	0.014	2.941	1.034	63- 18
0.610	2.924	0.016	0.005	2.941	1.006	69- 37
0.630	2.922	0.018	0.006	2.944	1.008	69- 37
0.650	2.910	0.018	0.006	2.947	1.013	69- 37
0.650	2.993	0.028	0.009	2.947	0.985	70- 44
0.650	3.044	0.045	0.015	2.947	0.968	70- 44
0.670	2.926	0.019	0.006	2.950	1.008	69- 37
0.690	2.932	0.019	0.006	2.953	1.007	69- 37
0.700	2.952	0.026	0.009	2.955	1.001	72- 43
0.700	2.919	0.017	0.006	2.955	1.012	72- 45
0.700	3.027	0.038	0.013	2.955	0.976	70- 44
0.700	2.940	0.023	0.008	2.955	1.005	72- 43
0.725	2.925	0.015	0.005	2.959	1.012	69- 37
0.750	2.953	0.046	0.016	2.963	1.003	70- 44
0.750	2.909	0.027	0.009	2.963	1.018	70- 44
0.775	2.945	0.015	0.005	2.966	1.007	69- 37
0.800	2.957	0.041	0.014	2.970	1.004	70- 44
0.800	2.970	0.024	0.008	2.970	1.000	72- 43
0.825	2.921	0.018	0.006	2.974	1.018	69- 37
0.850	2.938	0.040	0.014	2.978	1.014	70- 44
0.850	2.973	0.029	0.010	2.978	1.002	70- 44
0.875	2.957	0.018	0.006	2.982	1.008	69- 37
0.890	2.992	0.070	0.023	2.984	0.997	70- 38
0.900	2.956	0.020	0.007	2.986	1.010	72- 43
0.900	2.943	0.014	0.005	2.986	1.014	72- 45
0.900	2.972	0.041	0.014	2.986	1.005	63- 18
0.925	2.940	0.021	0.007	2.990	1.017	69- 37
0.950	3.002	0.028	0.009	2.993	0.997	70- 44
0.960	2.971	0.060	0.020	2.995	1.008	70- 38
0.975	2.942	0.021	0.007	2.997	1.019	69- 37
0.990	3.061	0.053	0.017	3.000	0.980	65- 15
0.990	2.977	0.060	0.020	3.000	1.008	70- 38
1.000	2.994	0.029	0.010	3.001	1.002	72- 43
1.025	2.972	0.026	0.009	3.005	1.011	69- 37
1.030	3.015	0.046	0.015	3.006	0.997	70- 38
1.050	3.011	0.028	0.009	3.009	0.999	70- 44
1.070	2.975	0.046	0.015	3.012	1.012	70- 38
1.075	2.999	0.031	0.010	3.013	1.005	69- 37
1.100	3.019	0.046	0.015	3.016	0.999	70- 38
1.100	3.020	0.019	0.006	3.016	0.999	72- 43
1.125	3.015	0.029	0.010	3.020	1.002	69- 37
1.140	3.055	0.047	0.015	3.023	0.989	70- 38
1.150	2.997	0.023	0.008	3.024	1.009	72- 43
1.150	3.035	0.028	0.009	3.024	0.996	70- 44
1.170	3.032	0.046	0.015	3.027	0.998	70- 38
1.175	2.984	0.034	0.011	3.028	1.015	69- 37
1.200	2.980	0.020	0.007	3.032	1.017	72- 43
1.220	3.027	0.046	0.015	3.035	1.003	70- 38
1.225	3.037	0.041	0.014	3.036	1.000	69- 37

Table 7 (contd)

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF	
1.250	3.098	0.020	0.006	3.040	0.981	72-	43
1.260	2.951	0.045	0.015	3.041	1.031	70-	38
1.275	3.055	0.038	0.012	3.043	0.996	69-	37
1.300	2.987	0.045	0.015	3.047	1.020	70-	38
1.300	3.064	0.029	0.009	3.047	0.995	72-	43
1.300	2.980	0.020	0.007	3.047	1.023	72-	45
1.325	3.096	0.047	0.015	3.051	0.986	69-	37
1.340	3.094	0.047	0.015	3.053	0.987	70-	38
1.360	3.024	0.018	0.006	3.056	1.011	69-	37
1.360	3.024	0.010	0.003	3.056	1.011	69-	37
1.375	2.998	0.042	0.014	3.059	1.020	69-	37
1.390	3.084	0.047	0.015	3.061	0.993	70-	38
1.400	3.094	0.028	0.009	3.063	0.990	72-	43
1.490	3.103	0.047	0.015	3.077	0.991	70-	38
1.500	3.094	0.029	0.009	3.078	0.995	72-	43
1.540	3.129	0.047	0.015	3.084	0.986	70-	38
1.600	3.100	0.045	0.015	3.093	0.998	70-	38
1.600	3.096	0.033	0.011	3.093	0.999	72-	43
1.600	3.033	0.021	0.007	3.093	1.020	72-	45
1.660	3.066	0.045	0.015	3.103	1.012	70-	38
1.720	3.107	0.047	0.015	3.112	1.002	70-	38
1.780	3.167	0.040	0.015	3.121	0.986	70-	38
1.850	3.181	0.040	0.015	3.132	0.985	70-	38
1.870	3.104	0.021	0.007	3.135	1.010	69-	37
1.900	3.106	0.019	0.006	3.140	1.011	72-	45
1.910	3.184	0.048	0.015	3.141	[illegible]	70-	38
1.970	3.207	0.048	0.015	3.150	0.982	70-	38
1.990	3.127	0.040	0.013	3.154	1.008	65-	15
2.050	3.127	0.047	0.015	3.163	1.011	70-	38
2.140	3.140	0.047	0.015	3.177	1.012	70-	38
2.230	3.194	0.048	0.015	3.190	0.999	70-	38
2.330	3.139	0.027	0.009	3.206	1.021	69-	37
2.360	3.191	0.048	0.015	3.210	1.006	70-	38
2.450	3.173	0.022	0.007	3.224	1.016	69-	37
2.490	3.273	0.049	0.015	3.231	0.987	70-	38
2.590	3.267	0.049	0.015	3.246	0.994	70-	38
2.670	[illegible]	0.057	0.017	3.258	0.987	70-	38
2.750	3.283	0.056	0.017	3.277	0.998	70-	38
2.980	3.262	0.016	0.005	3.306	1.013	69-	37
3.000	3.199	0.049	0.015	3.309	1.034	65-	15
3.010	3.327	0.057	0.017	3.311	0.995	70-	38
3.210	3.377	0.061	0.018	3.341	0.989	70-	38
3.340	3.358	0.061	0.018	3.361	1.001	70-	38
3.500	3.322	0.022	0.007	3.386	1.019	69-	37
3.520	3.350	0.061	0.018	3.389	1.012	70-	38
3.720	3.342	0.067	0.020	3.420	1.023	70-	38
3.900	3.385	0.039	0.012	3.448	1.019	63-	18
3.930	3.381	0.025	0.007	3.452	1.021	69-	37
3.940	3.400	0.075	0.022	3.454	1.016	70-	38
4.020	3.280	0.050	0.015	3.466	1.057	65-	15

Table 7 (contd)

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF	
4.030	3.417	0.017	0.005	3.468	1.015	69-	37
4.050	3.539	0.078	0.022	3.471	0.981	70-	38
4.220	3.436	0.070	0.020	3.497	1.018	68-	46
4.230	3.519	0.089	0.025	3.498	0.994	70-	38
4.350	3.512	0.089	0.025	3.517	1.001	70-	38
4.430	3.451	0.029	0.008	3.529	1.023	69-	37
4.490	3.620	0.091	0.025	3.539	0.977	70-	38
4.540	3.511	0.022	0.006	3.546	1.010	69-	37
4.700	3.643	0.109	0.030	3.571	0.980	70-	38
4.940	3.534	0.028	0.008	3.608	1.021	69-	37
5.060	3.577	0.017	0.005	3.626	1.014	69-	37
5.570	3.636	0.027	0.007	3.705	1.019	69-	37
5.910	3.704	0.070	0.019	3.757	1.014	68-	46
5.980	3.686	0.042	0.011	3.768	1.022	69-	37

Table 8. Comparison of calculated values of $\bar{\nu}$ for Pu^{240} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF
0.100	2.844	0.190	0.067	2.816	0.990	66- 47
1.000	2.509	0.350	0.139	2.960	1.180	66- 47
1.080	3.103	0.155	0.050	2.973	0.958	70- 38
1.150	3.185	0.160	0.050	2.984	0.937	70- 38
1.230	2.984	0.129	0.043	2.997	1.004	70- 38
1.310	3.004	0.105	0.035	3.010	1.002	70- 38
1.390	3.003	0.105	0.035	3.023	1.007	70- 38
1.460	3.017	0.111	0.037	3.034	1.006	70- 38
1.540	3.156	0.101	0.032	3.047	0.965	70- 38
1.600	3.012	0.120	0.040	3.056	1.015	66- 47
1.620	3.224	0.096	0.030	3.060	0.949	70- 38
1.710	3.134	0.095	0.030	3.074	0.981	70- 38
1.810	3.228	0.091	0.028	3.090	0.957	70- 38
1.870	3.072	0.055	0.018	3.100	1.009	74- 48
1.920	3.202	0.089	0.028	3.108	0.971	70- 38
2.020	3.139	0.103	0.033	3.124	0.995	70- 38
2.150	3.116	0.103	0.033	3.144	1.009	70- 38
2.290	3.243	0.113	0.035	3.167	0.977	70- 38
2.390	3.226	0.113	0.035	3.183	0.987	70- 38
2.450	3.160	0.051	0.016	3.192	1.010	74- 48
2.500	3.396	0.126	0.037	3.200	0.942	70- 38
2.620	3.330	0.113	0.034	3.220	0.967	70- 38
2.740	3.290	0.132	0.040	3.239	0.984	70- 38
2.880	3.411	0.137	0.040	3.261	0.956	70- 38
2.900	3.279	0.045	0.014	3.277	0.999	74- 48
3.020	3.384	0.142	0.042	3.284	0.970	70- 38
3.180	3.445	0.155	0.045	3.309	0.961	70- 38
3.500	3.279	0.051	0.016	3.360	1.025	74- 48
3.530	3.462	0.156	0.045	3.365	0.972	70- 38
3.730	3.368	0.169	0.050	3.397	1.009	70- 38
3.940	3.468	0.199	0.057	3.431	0.989	70- 38
4.030	3.353	0.055	0.016	3.445	1.027	74- 48
4.540	3.526	0.075	0.021	3.527	1.000	74- 48
5.060	3.544	0.071	0.020	3.610	1.019	74- 48
5.810	3.659	0.059	0.016	3.730	1.019	74- 48

Table 9. Comparison of calculated values of $\bar{\nu}$ for Pu^{241} with experimental values. The calculated values were obtained using Eq. (8).

NEUTRON ENERGY	NUBAR EXP.	DNUBAR EXP.	DNU/ NUBAR	NUBAR CALC.	CALC./ EXP.	YR-REF	
0.	2.956	0.100	0.034	2.901	0.981	55-	20
0.	2.849	0.015	0.005	2.901	1.018	69-	49
0.	2.901	0.124	0.043	2.901	1.000	56-	26
0.	3.087	0.050	0.016	2.901	0.940	59-	21
0.	2.825	0.176	0.062	2.901	1.027	61-	50
0.	2.899	0.026	0.009	2.901	1.001	65-	24
0.	2.950	0.029	0.010	2.901	0.983	55-	19
0.	3.111	0.110	0.035	2.901	0.933	58-	25
0.	2.906	0.008	0.003	2.901	0.998	67-	22
0.520	2.860	0.110	0.038	2.987	1.045	68-	46
1.870	3.158	0.053	0.017	3.211	1.017	74-	48
2.450	3.207	0.034	0.011	3.308	1.031	74-	48
2.710	3.337	0.110	0.033	3.351	1.004	68-	46
2.980	3.320	0.028	0.008	3.396	1.023	74-	48
3.500	3.330	0.033	0.010	3.482	1.046	74-	48
4.030	3.472	0.042	0.012	3.570	1.028	74-	48
4.190	3.466	0.100	0.029	3.597	1.038	68-	46
5.060	3.629	0.073	0.020	3.741	1.031	74-	48
5.880	3.804	0.120	0.032	3.877	1.019	68-	46

Table 10. Comparison of calculations using Eq. (8) with the experimental data of reference 49.

Nuclide	$\bar{\nu}$ Exp	$\bar{\nu}$ Calc	$\bar{\nu}$ Calc/$\bar{\nu}$ Exp
Th^{229}	2.06 ± .02	1.99	0.966
U^{232}	3.10 ± .06	2.37	0.764
U^{233}	2.46 ± .01	2.45	0.996
U^{235}	2.385 ± .005	2.383	0.999
Pu^{238}	2.87 ± .03	2.81	0.979
Pu^{239}	2.86 ± .01	2.85	0.997
Pu^{241}	2.85 ± .02	2.90	1.018
Am^{241}	3.19 ± .04	2.94	0.922
Am^{242m}	3.23 ± .02	3.18	0.984
Cm^{243}	3.40 ± .05	3.41	1.003
Cm^{245}	3.80 ± .03	3.38	0.889